STANDARDISATION OF POTTING SOILS IN THE BENELUX

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Introduction

Potting soils are made from very different organic as well as inorganic materials. In the past, each gardener made hiw own potting soils. Nowadays there are specialized industries, manufacturing potting soils on a large scale. In the interest of the horticulture, the potting soils coming into the market, should meet certain minimum requirements. In the Benelux, therefore, a regulation was drafted, in which a number of minimum requirements for potting soils are given.

Situation in The Netherlands

Two investigations are referred here which demonstrate the situation as to the quality of potting soils, marketed in The Netherlands. The first investigation (Arnold Bik et al., 1964; Van der Boon and Arnold Bik, 1965; Van der Boon et al., 1967) concerns 30 brands of potting soils, traded in small plastic bags and destined for domestic use. The bags were purchased in different florist shops in arbitrarily chosen towns. The potting soils were morphologically and physically examined, and chemically analyzed. A vegetation test was made with Gloxinia.

There was found to be a wide variation in the composition of the potting soils. Most of them were mixtures of two or more of the following materials: peat moss, strongly decomposed "black" peat, town refuse compost, farmyard manure, pine-forest litter, leaf mould, sand and limestone, to which inorganic fertilizers were added. It was not possible to estimate the percentages of the various ingredients by morphological analysis.

The chemical composition of most potting soils left much to be desired, especially with respect to water-soluble phosphate. Only six soils contained enough water-soluble phosphate, taking 15 mg P_2O_5 per 100 g air-dry soil as the lower limit. In many cases also other chemical characteristics of the soils were inadequate: in 8 of the 30 soils the salt content must be considered too high, in 16 soils the available nitrogen was too low, etc.

Accordingly, the test plant Gloxinia showed great differences in dry-matter production, the lowest yield being 0.80 g and the highest 2.58 g. There was a statistically significant relation with the water-soluble phosphate and potassium contents of the soil: for an optimum yield a P-water of 12 mg P_2O_5 per 100 cm3 and a K-water of 18 mg K_2O per 100 cm3 are required. No clear influence of the physical properties on the growth of Gloxinia was found, probably because the pots were bedded in humid peat moss.

Secondly, reference is made of an investigation of Spithost (1969) of potting soils used by commercial vegetable growers. Even here, the situation was far from ideal. Based on the fresh weight of tomato plants, propagated on soil blocks, only 30% of the 56 tested soils used by vegetable growers, could be considered good, the remaining 70% ranging from inadequate to totally unsuitable. There was a great diversity in chemical and physical properties of the potting soils. The organic-matter content ranged from 10 to 76%, N-water from 4 to 127 mg and P-water from 2 to more than 40 mg P_2O_5 per 100 g of dry soil, etc. The main factor which dominated the growth of the young tomato plants was found to be water-soluble nitrogen. Optimum nitrogen condition was achieved at a "N-value" of 35 mg N per 100 ml of soil. The physical condition of the soil blocks was also of influence on the growth of the tomato plants. Air-filled pores at pH 1.0 should amount to at least 6 Vol.% or the organic fraction, present in particles larger than 1000 mu, should constitute more than 30% of total organic matter. Since there is a strong relation between the performance of the tomato plants in the soil blocks, and the ultimate yield of tomatoes in the glasshouse, a poor quality of the potting soil will result in high financial losses in vegetable growing. These investigations emphasize the strong need of a regulation which excludes potting soils of poor quality from the market.

Design of a regulation in the Benelux

In cooperation with specialists of Belgium and Luxemburg a regulation is designed, in which a number of minimum requirements are given for the physical and chemical quality of potting soils. On account of the great number of materials, which can be used in an appropriate formulation for the preparation of potting soils, and of the great variety of plants, for which the potting soils must be used, no narrow standards could be set up. Only limits are drawn, beyond which entirely insufficient growth for most plants has to be expected. Potting soils with properties just within the given limits, are considered to be potentially suitable as a growing medium for most plants with no peculiar demands. To achieve optimum yields suitable culture measures must be taken: e.g. mixing with other substances, an adapted water regime and timely top dressing.

The main features of the proposed classification and standards are given in table 1. The potting soils are classified in the following groups:

1a. Potting soil (for general use in pots or blocks for the propagation of vegetables, tomato plants, etc.).
 b. Potting soil with low nutrient level.
 c. Potting soil with high nutrient level.

1b and 1 c only deviate from 1a in respect to their N- and K-levels, which are the same as for the corresponding potting soils for pot plants (see table 1).

2a. Potting soil for pot plants (floriculture), except acidophyl plants, Anthurium scherzerianum, Anthurium andreanum and orchids.
 b. Potting soil for pot plants, with low nutrient level.
 c. Potting soil for pot plants, with high nutrient level.

3. Potting soil for acidophyl pot plants, for Ericaceae, Gardenia, Camellia or Ixora.

The group name of the potting soil must be followed by an enumeration of the bulky ingredients in order of decreasing percentage. The permitted ingredients are: peat, peat moss, horticultural peat (more decomposed raised bog peat, which has been frozen in wet condition), decomposed farmyard manure, leaf mould, forest litter, sand, clay (including perlite and vermiculite). For each of the potting soils, it is allowed to give a guarantee for a minimum content of organic matter, and for a maximum content of water-soluble salts and of chloride.

Discussion of some basic principles underlying the designed regulation

In several countries there is a strong tendency to the development of potting "soils" on a pure peat basis. Particularly peat moss is taken for a substrate which, regarding physical properties, is getting near the ideal, e.q. Puustjärvi (1968), Woods et al (1968). To obtain sufficient coherence in soil blocks, a mixture of peat moss and more decomposed fresh peat can be used (Roorda van Eysinga, 1965). De Boodt (1965), however, suggests the admixture of sand or perlite, depending on culture purposes, which is also the opinion of some Dutch specialists. Optimum results can also be achieved, using other types of peat as a substrate (e.q. Atkins, 1968) and, in certain cases, even when using no peat at all.

The aim of the designed regulation is not primarily to simplify cultural programmes or to reduce the costs of production, but to exclude potting soils of inferior intrinsic quality. Standards are drafted for physical and chemical properties, no prescriptions are given how these properties are to be realized. The standards, mentioned in table 1, clearly are minima or maxima, not optima. A certain margin is not only technically inevitable, but plants also diverge in their demands as to physical and chemical properties of the potting media (of which demands often still much is left to be known). To reduce the number of groups, the margin had to be rather large.

As for the physical properties, the quality of the potting soil is determined by the quantity of available water and air under normal culture conditions. The plants are normally grown at fairly low moisture tension, averaging about 30 cm (pF ca. 1.5). For pot plants, growth conditions are considered to be good if the volume percentages of solid, water and air, at pF 1.5, are less than 25, more than 45 and more than 25 respectively (Arnold Bik, private comm.). De Boodt (1965) gives as an ideal ratio at pF 1.5, about 20:45:35. A high volume percentage of water decreases the risk of salt damage and makes a somewhat heavier dressing possible (Arnold Bik, 1961). This explains why a volume percentage of water of 40 and a volume percentage of air of 20 were taken as limits for potting soils for pot plants. For potting soils (for vegetables etc.) no standard was mentioned for the air content, since for propagating vegetables on soil blocks, which is common practice in The Netherlands, the air content of the soil is considered to be of less influence (the blocks are surrounded by air at five sides). So, Roorda van Eysinga (1965) did not find a significant relation between plant size and volume percentage of air at pF 0.4. Spithost (1969), on the other hand, recently obtained indications that the air volume may be critical. From an experiment with 56 potting soils, it was concluded that at least 6% air-filled pores must be present at pF 1.0.

The purpose of the standard for the water capacity (after drying) of the potting soil for pot plants is to exclude strongly irreversibly drying-out soils, such as is the case when too much freshly cut, decomposed peat is used. Except that the re-uptake of water is insufficient, the serious shrinkage at drying often damages the roots. Van Dijk and Boekel (1965) have shown that the water capacity of decomposed peat after air-drying can be easily maintained at a value of more than 4 times the organic-matter content if the peat is frozen in fresh condition. This standard implies that strongly irreversibly drying peat can only be used if it is thoroughly mixed with other materials, which increases the reversibility of drying.

As to the chemical properties, there are great differences between plants in respect of nutrient demands and susceptibility for salt damage. Therefore three divergent levels for contents of total salt, and of nutrients have been entered in the regulation. Penningsfeld (1960) also classifies the flower plants into three groups. The classification is, however, schematic. In the main period of the growth a certain nutrient level may be too low, whereas the same level may cause salt damage in a rest period.

In these standards, nutrients becoming available from organic materials or from slowly releasing organic fertilizers have not been taken into account. On drafting the standards, the line was taken that the potting soils must contain an amount of nutrients, sufficient for the first stage of growth of the plants. In following stages top dressing must be applied to satisfy the need of the plant, unless the supply from mineralization or release of nutrients is sufficient. In this connection it is important to know the nature of the added materials.

Ample discussions were devoted to the question, on what basis the nutrient level must be expressed: on dry-matter weight, on volume, or on the amount of available water. The preparation of potting soils is most easily performed by mixing the bulky ingredients on volume basis, and by adding fertilizers as weights per volume. A varying moisture content has much greater influence on the weight of the materials than on their volume. A second argument in support of volume basis is, that the plant in a soil block or in a pot disposes of a fixed soil volume. In the experiment with Gloxinia grown on 30 widely varying commercial potting soils (Van der Boon et al., 1967) correlation coefficients were calculated between plant-response and soil-analysis data, based on weight and based on volume of the dry soil (table 2). Except for magnesium, the correlation coefficients for soil analysis data based on volume of soil were higher.

Spithost (1969) related fresh weight of young tomato plants, propagated on soil blocks, with N-water, calculated as mg per 100 g of dry soil. In the regression equatation a negative relation emerged with the organic-matter content of the soil, the partial correlation coefficient being -0.44. This is readily explained by the fact that with the same amount of nitrogen per 100 g of dry soil, the amount of nitrogen per soil block is lower, the higher the organic matter content, bringing about a lower volume weight. To avoid that complication, Spithost introduced the N-value, i.e. the amount of water-soluble nitrogen expressed on the basis of volume, viz. mg N per 100 ml of soil.

Spithost calculated the volume weight from the organic-matter content after the equation: volume weight (g/ml) = 3.1 x % org. matter - 0.61. In the designed regulation, the standards for N, K, and salt, have been put directly proportional to the organic-matter content. In the range of 20 to 40% organic matter, in which most potting soils fall, the relation with volume weight may be approximately rectilinear, making it not essentially different whether the organic-matter content or the volume weight is taken as a basis for the standards. If, however, the volume weight is the right basis, than the given standards cannot be correct for a wider range of organic-matter contents, for the relation between organic-matter content and volume weight is curvilineal. In that case it would even be preferable to determine the volume weight directly, as is proposed by Lucas and Rieke (1968), in stead of calculating it from the organic-matter content.

The question arises then, however, which is the best way of determining, i.e. how the structure of the potting soil, as used in culture practice, can be imitated best. Boekel and Van Lokhorst (1964) demonstrated that the pressure at filling the measuring device, in connection with the moisture content, influences the pore distribution and, therefore, the solid-water-air ratio rather differently for different potting media. To obtain favourable water and air contents, some potting soils should be pressed slightly at filling, others heavier.

There are also some indications that perhaps the best basis for expressing the salt and nutrient content would be the amount of water present in the soil, i.e. giving it in terms of concentration of the soil solution. For example, Arnold Bik (1962) found a distinct interaction between the effect of organic-matter content and that of the amount of fertilizing. In his experiments with Cyclamen and Gloxinia an increase of the peat content of the potting mixture caused an increase of the nitrogen effect at sub-optimum rates and, beyond the optimum, a decrease of the negative effect of salt excess. The moisture volume of the potting medium is here assumed to play a predominant part.

On the other hand, in the experiment with 30 commercial potting soils (Van der Boon et al., 1967) the correlation coefficients between plant response and the soil analysis data, based on volume of water at pH 1.5 (last column of table 2), were not higher than when the analysis data were based on volume of soil. We found the relation between the volume % of moisture at pF 1.5 and the organic-matter content of potting soils in the range of 20 to 40% organic matter to be roughly linear. This relation, however, is also certainly not rectilinear for a wider range, including potting "soils" on pure peat basis. Upon determining the volume percentage of water at pF 1.5, the same difficulty is met as in the determination of the volume weight, viz. which pressure and moisture content should be applied at filling the measuring devices (the drafted instruction mentions a pressure of 0.5 kg/cm2 at pF 2.0).

At this moment still no definite answer can be given on the question of the most correct basis (from the plant's point of view) for expressing salt and nutrient contents. Therefore, for the time being, the practice in advising fertilizing of soils in glasshouses was followed. There the soil analysis data are expressed on the basis of dry-matter weight and related to the organic-matter content of the soil. This refers to water soluble salts, chloride, nitrogen and potassium. To avoid extreme N/K ratios, the standard for potassium content is made dependent on the nitrogen content.

For phosphate no clear influence of the organic-matter content on its interpretation has been found in normal garden soils. Therefore the standard for water-soluble phosphate was not related to the organic-matter content, although there are indications that for potting soils this is not quite correct (table 2).

As for the minor elements, at the moment no nutrient standards have been drafted, because of lack of sufficient knowledge of the critical range of the soil analysis data. The purpose of the standard for iron is to prevent the use of certain iron-rich peats of inferior quality. Potting-soil producers are, however, advised how much of the minor elements should be admixed. For raised bog peat, per litre the following amounts of minor elements are recommended: 1.5 mg Cu, 0.5 mg B, 3.0 mg Mo, 0.75 mg Zn and 2.50 mg Mn. If the potting soil contains other ingredients than peat moss or horticultural peat, the rate of minor elements generally can be decreased in proportion to the volume percentage of these other materials. It is evident that this general recipe does not satisfy the demands of all plants. For example, for cauliflower it is necessary to add considerably more molybdenum (Roorda van Eysinga, 1965). In the recommended pH range the addition of Fe-chelates did not seem to be necessary.

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Summary

The confusing situation in the field of potting soils, as they are composed from different materials and fertilized up to divergent levels, urged in the Benelux to a classification of these soils, depending on culture purposes and to a drafting of physical and chemical standards. The paper gives a short discussion of the proposed classification and the standards for organic-matter content, water and air conditions, pH, salt content and level of plant nutrients.

Zusammenfassung

Die unübersichtliche Situation auf dem Gebiete der Topferden, die hergestellt werden aus allerhand Ausgangsmaterialien und dazu in unterschiedlicher Höhe mit Düngemitteln versehen werden, veranlasste zu einer Klassifizierung von Topferden im Benelux und zu einem Entwurf von physikalischen und chemischen Normen.

Die vorgeschlagene Einteilung und die Grenzwerte für den Gehalt an organischer Substanz, das Wasser- und Luftvolume, pH, Salzgehalt und Versorgung mit Pflanzennährstoffen werden kurt erörtert.

Table 1 - Main features of the proposed classification and standards for potting soils in the Benelux

	Potting soils (for vegetables, tomatoes etc.)	Potting soils for pot plants (floriculture)			
		nutrient level			acidophyl plants, Ericaceae etc.
		low	medium	high	
a. % org. matter	>20		>20		>60
b. % mineral particles <16 mu	-		-		< 5
c. Vol. % moisture) at pF 1.5	>40		>40		>40
d. Vol. % air) at pF 1.5	-		>20		>20
e. watercap. after air drying	-		> 4a		> 4a
f. pH-water (20-40% org. m. / (> 40% org. m.	5.5-7.0) / 5.0-6.5)		5.5-6.5		4.0-4.5
g. % water soluble salts	<0.05a	<0.02a	<0.03a	<0.05a	<0.01a
h. % Cl	<0.004a		<0.002a		<0.001a
i. water-soluble N	1.0a-2.5a	0.5a-1.5a	1.0a-2.5a	2.0a-3.5a	0.5a-1.5a
j. water-soluble K (as K_2O)	0.8i-2.5i		0.8i-2.5i		0.8i-2.5i
k. water-soluble P (as P_2O_5)	>20	>20	>30	>40	>20
l. Fe (Morgan solution)	< 6		< 6		< 6
m. Mg (Morgan solution)	-		> 1.5a		> 1.5a

a, g, h: calculated on dry-matter base
i-m : mg per 100 g of dry matter
e : g water, at pF 1, per 100 g of dry matter
f : soil/water ratio = 1/10
g-k : soil/water ratio = 1/25
l, m : soil/Morgan solution = 1/10

>, < = at least, at most
>4a = at least 4 x % org. matter, etc.
no figures in column for low and high nutrient level means: same as for medium
- means: no standards drafted

Table 2 - Correlation of crop- and leaf-analysis data with available nutrient content of the soil, calculated on basis of weight and of volume of soil and of volume of water at pF 1.5

Plant		Soil	Correlation coefficients		
			per weight of soil	per volume of soil	per 100 ml water at pF 1.5
dry matter yield	vs	N-water	+0.18	+0.24	+0.24
		P-water	+0.50	+0.63	+0.63
		K-water	+0.17	+0.31	+0.27
leaf analysis:N%	vs	N-water	+0.81	+0.87	+0.86
P%	vs	P-water	+0.78	+0.88	+0.85
K%	vs	K-water	+0.52	+0.85	+0.83
Mg	vs	Mg-morgan	+0.47	+0.29	+0.26
Cl%	vs	NaCl-water	+0.34	+0.41	+0.41